(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number : **0 651 522 A1**

(12) EUROPEAN PATENT APPLICATION

(21) Application number : **94308041.6**

(51) Int. Cl.[6] : **H04B 1/26,** H03D 7/18

(22) Date of filing : **01.11.94**

(30) Priority : **01.11.93 FI 934832**

(43) Date of publication of application :
03.05.95 Bulletin 95/18

(84) Designated Contracting States :
DE ES FR GB SE

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(54) Image rejection frequency convester as multi-band receiver.

(57) The circuit arrangement according to the invention utilizes both outputs of an image rejection, whereby one of the desired frequency bands is obtained from a "signal port" and the other desired frequency band from the image "signal port". Thus a desired intermediate frequency signal band (IF) corresponding to the radio frequency input signal (RF) can be selected using a switch (24), the intermediate frequency signal band (IF) being filtered by an intermediate frequency filter (20,22). The frequency (LO) of the local oscillator is selected to be in the middle of the radio bands (RF).

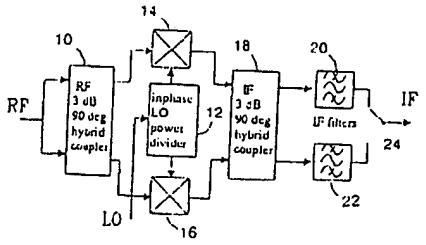

Fig. 2

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Various methods are used in radio communications systems for duplex operations. Conventional analog systems generally employ Frequency Division Duplex (FDD). Two different frequency bands are used; one for reception and one for transmission.

Time Division Duplex (TDD) is viable in digital systems. For example, the DECT system (Digital European Cordless Telecommunications) uses TDD. In this case the transmitter (Tx) and the receiver (Rx) operate on the same frequency band, only in different time slots.

In some future telecommunications systems such as the UMTS (Universal Mobile Telecommunication System) the system may have to be able to switch from the FDD state into the TDD state and vice versa. Two FDD bands would most likely be used in actual systems, the one upwards (uplink) to the base station and the other one downwards (downlink) from the base station to a mobile phone, for instance, and a third frequency band for TDD operations. Thus both the receiver and the transmitter must switch their operating frequencies when the radio part is coupled from the FDD state to the TDD state and vice versa. In the intermediate frequency a different bandwidth is typically used in the FDD state than in the TDD state. This means that the receiver must also switch the bandwidth of the intermediate frequency at the same time as the band of the operating frequency is switched.

Where the receiver must switch its operating frequency band between two frequency bands, the changing over can be carried out by switching the frequency of the local oscillator. At the same time, the passband of the bandpass filter of radio frequency preceding the mixer should be switched so that it passes the right frequency band. Alternatively, two bandpass filters can be used, one of which is respectively coupled to the signal route using two switches. The switching of the frequency of the local oscillator can be considerable and it is not easy to implement using the same synthesizer. On the other hand, using two switchable synthesizers in the local oscillator is a far more complicated task.

The switch of the bandwidth of the intermediate frequency is normally carried out using two filters and two switches through which the required filter is coupled to the signal route. Alternatively, filters with different bandwidths can be coupled in series, as disclosed in US patent 4,385,402.

An image reject mixer comprises a 3 dB radio frequency hybrid coupler with a 90 degree phase switch, an inphase power divider of the local oscillators, two mixers, and a 3 dB intermediate frequency hybrid. The desired signal is summed inphasally in the intermediate frequency hybrid to another intermediate frequency output port and cancelled in the other intermediate frequency output port. In the same way, the image signal is summed in the one port and cancelled in the port in which the desired signal is summed. Generally the port of the image signal is terminated and the port of the desired signal is used as the intermediate frequency output port.

Fig. 1 shows schematically a circuit arrangement according to prior art which can be used to switch the frequency of a receiver and which was described in a general way at the beginning. A radio frequency signal RF coming from an antenna (not shown), for instance, is directed to a bandpass filter (RF filter), and further into a mixer to be mixed by the frequency LO of the local oscillator, from where the intermediate frequency signal is directed to an intermediate frequency filter (IF filter), and from there to the output as a desired intermediate frequency output signal IF. The medium frequency of the intermediate frequency signal directed to the output can be switched by switching frequency LO of the local oscillator. However, also the RF and IF filters must then be switched so that they pass the desired band, respectively. Therefore, the RF and IF filters of Fig. 1 are duplicated. The frequency switching is carried out in the case of Fig. 1 by switches s1 - s4 which are used to couple the desired RF filter and IF filter, respectively, to route RF - IF. The properties of the bandpass filters (RF, IF), i.e., the medium frequency and bandwidth are dimensioned in accordance with respective requirements in a manner known per se. As previously mentioned, the frequency switching of the local oscillator may lead to problems in practice.

In accordance with a first aspect of the present invention there is provided a circuit arrangement for switching the frequency range of a radio receiver, utilizing image frequency bands, whereby the frequency of a local oscillator is adapted approximately to the middle of two selected frequency bands, characterised in that the circuit arrangement comprises

- a mixer attenuating the image frequency, an intermediate frequency corresponding to the first frequency band being obtained from the first output of the mixer, and an intermediate frequency corresponding to the second frequency band being obtained from the second output, and
- a switch for selecting a desired intermediate frequency corresponding to the frequency band either from the first or the second output of the mixer.

In accordance with a second aspect of the present invention there is provided a circuit for switching the frequency range of a radio receiver between first and second frequency bands comprising:

- means for providing a local oscillator signal having a frequency between the first and second frequency bands;
- means for mixing the local oscillator signal and a received signal to provide an output signal;
- means for providing the output signal to a first

output if the received signal is within the first frequency band and to a second output if the received signal is within the second frequency band; and

- means for selecting the first or second output depending on the frequency band of the received signal.

The invention utilizes a circuit that could be used as an image rejection frequency converter to provide output signals down converted from a first frequency band to a first output and output signals down converted from a second frequency band to a second output, providing a simple arrangement for switching the frequency range of a radio receiver.

The invention provides a circuit arrangement utilizing the image frequency bands for switching the frequency and bandwidth of the receiver, which can be used to simplify the circuit structure compared to prior art.

The circuit arrangement according to the invention utilizes both outputs of a mixer which attenuates the image frequency, whereby one of the desired frequency bands is obtained from the "signal port" and the other desired frequency band from "the port of the image signal" which is generally not utilized in prior art image rejection frequency converters.

The invention is described in the following with the aid of the drawings in which:

Fig. 2 shows schematically a circuit solution according to the invention for switching the frequency and the bandwidth of the receiver; and

Fig. 3 shows, on a frequency axis, the placement of the local oscillator of the receiver approximately in the middle of the radio frequency bands coming into the receiver.

Fig. 2 shows a circuit arrangement according to the invention which can be used for switching the frequency and bandwidth in the simplest way. The circuit arrangement comprises:

- a radio frequency 3 dB hybrid coupler 1 (RF hybrid) with a 90 degree phase shift, comprising as its output the radio frequency signal RF from, for instance, an antenna;
- inphasal power divider 12 of output signal LO of a local oscillator (not shown), the outputs of the power divider being directed to the mixers;
- two mixers 14, 16, the outputs of which are directed to the respective input of the intermediate frequency hybrid;
- a 3 dB intermediate frequency hybrid coupler 18 (IF hybrid) with a 90 degree phase shift, the outputs of the hybrid being directed to the respective intermediate frequency filter;
- bandpass filters 20, 22, of the intermediate frequency, the outputs of which are directed to a selector switch; and
- selector switch 24 which is used to select a desired outcoming intermediate frequency as output IF.

The circuit arrangement in Fig. 2 utilizes both outputs of the mixer attenuating the image frequency, whereby one of the desired frequency bands is obtained from a "signal port" and the other desired frequency band from "the port of the image signal". Thus the frequency of the local oscillator must be selected so that it is approximately halfway between the desired frequency bands. On the other hand, intermediate frequency IF must also consist of approximately half of the difference between the medium frequency of the two selected frequency bands. This situation is schematically illustrated in Fig. 3 where the selected radio frequency bands are marked with RF1, RF2. In this way no major changes need to be carried out on the selected frequencies in frequency LO of the local oscillator, as the other selected intermediate frequency IF is switched to the output. Consequently, the selection of the bands can also be carried out using either one of the outputs of the mixer attenuating the image frequency.

Since the bandwidth of the intermediate frequency may change while the frequency is switched, two different intermediate frequency filters 20 and 22, respectively, can be coupled to the outputs of the mixer without using any switches. The advantage of this arrangement is that no switches are required before the filters, and therefore the fitting between the filter and mixer 18 can be optimized separately for each filter 20, 22. In fact, as compared with Fig. 1, only one switch 24 is required for the circuit arrangement of the invention instead of four switches s1 - s4, which significantly simplifies the circuit design.

Frequency LO of the local oscillator can be advantageously so selected that it is exactly in the middle of frequency bands RF1, RF2. Alternatively, frequency LO of the local oscillator can be so selected that it is not exactly in the middle of the bands but tuned to the side to given degree Df, in either direction. In the latter case frequency LO of the local oscillator must be switched to degree Df when changing the frequency band (RF1, RF2) directed to output IF. However, this frequency switch Df is considerably lower than in the case of Fig. 1, for instance, where no mixer attenuating the image frequency is used. Consequently, in the case of Fig. 2, both frequencies (LO; LO + Df or LO-Df) can be implemented in the local oscillator using the same synthesizer.

A system which comprises several frequency channels in frequency bands 2000 - 2050 MHz and 2200 - 2250 MHz can be mentioned as an example. Half of the differences of the medium waves of the radio bands, i.e., (2200+2250)/2 - (2050+2000)/2 = 100 MHz, can be selected as the intermediate frequency. Thus frequency LO of the signal of the local oscillator varies between 2100 - 2150 MHz depending on the channel. A 100 MHz intermediate frequency is obtained from both the signal port of the mixer and from

the image frequency port so that the signal of one of the ports corresponds to a lower frequency band and the signal of the other port to a higher frequency band. An intermediate frequency filter (such as the higher one of the intermediate frequency filters, IF filters, in Fig. 2) with a narrower band, such as 100 kHz, can be coupled to one of the ports, and an intermediate frequency filter (lower intermediate frequency filter, IF filter, in Fig. 2, for instance) with a wider band, such as 1 MHz, can be coupled to the other port. By selecting a signal from the output of either intermediate frequency filter, it is possible to choose whether to receive a narrow-band signal from the first frequency band or a wide-band signal from the second frequency band.

In some applications the attenuating properties of the mixer attenuating the image frequency (of the transmission frequency) are perhaps not sufficient. In such cases a switchable or tunable RF filter (not shown) can be used before the mixer to attenuate the transmission image frequency, the filter producing a higher attenuation on a selected frequency band.

The invention is advantageously applied in radio telephones and radio telephone systems which were referred to in the introductory part of the description. Naturally, the principle according to the invention can be modified within the scope of the Claims with respect to operating frequencies, bandwidths and structural details of the circuit arrangement. The details of the circuit arrangement with respect to the dimensioning is not disclosed in this description more closely because they are considered to be a part of the normal skills of those skilled in the art, which can be applied after reading this description.

The present invention includes any novel feature or combination of features disclosed herein either explicitly or any generalisation thereof irrespective of whether or not it relates to the claimed invention or mitigates any or all of the problems addressed.

In view of the foregoing description it will be evident that various modifications may be made within the scope of the invention.

Claims

1. A circuit arrangement for switching the frequency range of a radio receiver, utilizing image frequency bands, whereby the frequency of a local oscillator is adapted approximately to the middle of two selected frequency bands, characterised in that the circuit arrangement comprises
   - a mixer attenuating the image frequency, an intermediate frequency corresponding to the first frequency band being obtained from the first output of the mixer, and an intermediate frequency corresponding to the second frequency band being obtained from the second output, and
   - a switch for selecting a desired intermediate frequency corresponding to the frequency band either from the first or the second output of the mixer.

2. A circuit arrangement according to Claim 1, characterised in that an intermediate frequency filter is respectively coupled to the outputs of the mixer before the switch.

3. A circuit arrangement according to Claim 1 or 2, characterised in that the frequency of the local oscillator is fitted halfway between two selected frequency bands.

4. A circuit arrangement according to Claim 1 or 2, in which the frequency of the local oscillator is fitted slightly aside from the middle of the two selected frequency bands, characterised in that the frequency of the local oscillator is changed to a predefined degree, while the first and/or second output frequency is selected to the output using a switch.

5. A circuit arrangement according to any of the preceding Claims, characterised in that a switchable/tunable radio frequency filter is arranged in front of the mixer, the pass range of the filter being switched/tuned as desired in accordance with the respectively selected output frequency.

6. A circuit arrangement according to any of the preceding Claims 2 to 5, characterised in that the frequency of the local oscillator and the parameters of the bandpass filters of the mixer outputs are so selected that the intermediate frequencies respectively directed to the output, using the switch, have a predetermined bandwidth.

7. A circuit arrangement according to Claim 6, characterised in that the predetermined bandwidths are the same.

8. A circuit arrangement according to Claim 6, characterised in that the bandwidths are different.

9. A circuit arrangement according to any of the preceding Claims, characterised in that it comprises:
   - a radio frequency 3 dB hybrid coupler with a 90 degree phase shift,
   - a inphasal power divider of the local oscillator,
   - to mixers, and
   - a 3 dB intermediate frequency hybrid coupler with a 90 degree phase shift,
   - bandpass filters coupled to the outputs of the intermediate frequency hybrid, and

- a switch coupled to the outputs of the band-pass filters, the desired outcoming intermediate frequency being selected using the switch.

10. A circuit for switching the frequency range of a radio receiver between first and second frequency bands comprising:
    - means for providing a local oscillator signal having a frequency between the first and second frequency bands;
    - means for mixing the local oscillator signal and a received signal to provide an output signal;
    - means for providing the output signal to a first output if the received signal is within the first frequency band and to a second output if the received signal is within the second frequency band; and
    - means for selecting the first or second output depending on the frequency band band of the received signal.

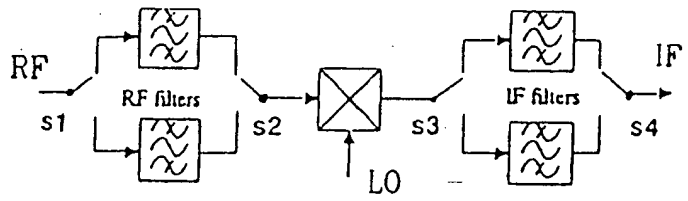

Fig. 1

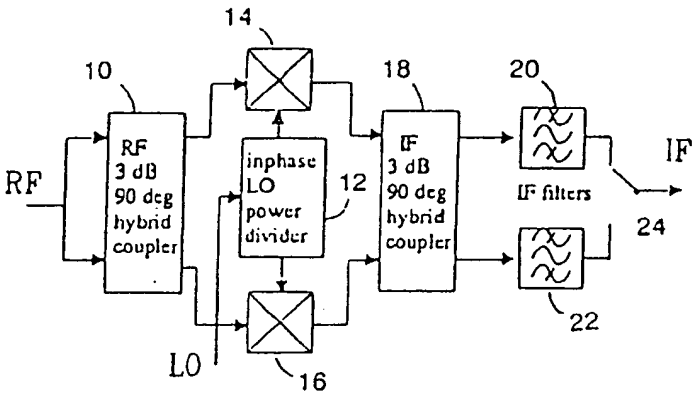

Fig. 2

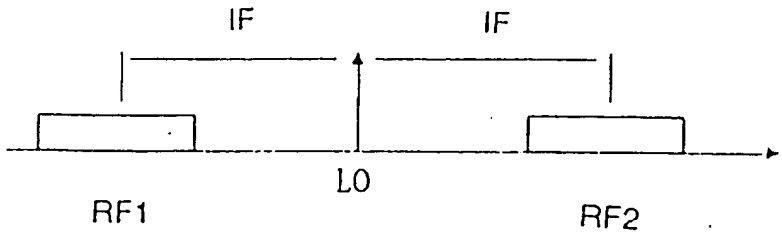

Fig. 3

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EUROPEAN SEARCH REPORT

Application Number
EP 94 30 8041

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
X A	US-A-5 214 796 (GORRIE ET AL.) * column 1, line 6 - column 2, line 55; figures 1,2,5 * * column 6, line 46 - line 57 *	1,3,10 2,4,5,7, 9	H04B1/26 H03D7/18
X	RF DESIGN, vol.16, no.4, April 1993, ENGLEWOOD, US pages 29 - 38 MAGIN 'A Robust Signaling Technique for Part 15 RF Control Network Applications'	1,3,10	
A	* page 37, line 10 - line 30; figure 12 *	2,4,5,7, 9	

TECHNICAL FIELDS SEARCHED (Int.Cl.6)

H04B
H03D

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	9 February 1995	Goulding, C

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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KORRIGIERTE FASSUNG

CORRECTED VERSION

VERSION CORRIGEE

☒ der Patentanmeldung
of the patent application
de la demande
0 651 522
A1

Veröffentlichungsdatum
Date of publication
Date de la publication
03.05.95

☐ der Patentschrift
of the patent specification
du fascicule de brevet

Veröffentlichungsdatum
Date of publication
Date de la publication

Die Berichtigung bezieht sich auf:
The amendment refers to:
La correction porte sur:

INID 54
INID 54
INID 54

Korrekturhinweis in Patentblatt Nr.
Mention of correction in Patent Bulletin No. **95/38**
Mention de la correction dans le bulletin nº

veröffentlicht am
published on
publié le **20.09.95**

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Korrigierte Fassung / Corrected Version / Version Corrigée

(54) Image rejection frequency converter as multi-band receiver.

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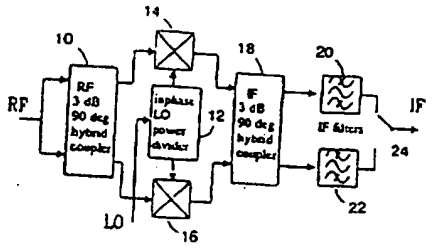

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Where the receiver must switch its operating frequency band between two frequency bands, the changing over can be carried out by switching the frequency of the local oscillator. At the same time, the passband of the bandpass filter of radio frequency preceding the mixer should be switched so that it passes the right frequency band. Alternatively, two bandpass filters can be used, one of which is respectively coupled to the signal route using two switches. The switching of the frequency of the local oscillator can be considerable and it is not easy to implement using the same synthesizer. On the other hand, using two switchable synthesizers in the local oscillator is a far more complicated task.

The switch of the bandwidth of the intermediate frequency is normally carried out using two filters and two switches through which the required filter is coupled to the signal route. Alternatively, filters with different bandwidths can be coupled in series, as disclosed in US patent 4,385,402.

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Fig. 1 shows schematically a circuit arrangement according to prior art which can be used to switch the frequency of a receiver and which was described in a general way at the beginning. A radio frequency signal RF coming from an antenna (not shown), for instance, is directed to a bandpass filter (RF filter), and further into a mixer to be mixed by the frequency LO of the local oscillator, from where the intermediate frequency signal is directed to an intermediate frequency filter (IF filter), and from there to the output as a desired intermediate frequency output signal IF. The medium frequency of the intermediate frequency signal directed to the output can be switched by switching frequency LO of the local oscillator. However, also the RF and IF filters must then be switched so that they pass the desired band, respectively. Therefore, the RF and IF filters of Fig. 1 are duplicated. The frequency switching is carried out in the case of Fig. 1 by switches s1 - s4 which are used to couple the desired RF filter and IF filter, respectively, to route RF - IF. The properties of the bandpass filters (RF, IF), i.e., the medium frequency and bandwidth are dimensioned in accordance with respective requirements in a manner known per se. As previously mentioned, the frequency switching of the local oscillator may lead to problems in practice.

In accordance with a first aspect of the present invention there is provided a circuit arrangement for switching the frequency range of a radio receiver, utilizing image frequency bands, whereby the frequency of a local oscillator is adapted approximately to the middle of two selected frequency bands, characterised in that the circuit arrangement comprises

- a mixer attenuating the image frequency, an intermediate frequency corresponding to the first frequency band being obtained from the first output of the mixer, and an intermediate frequency corresponding to the second frequency band being obtained from the second output, and
- a switch for selecting a desired intermediate frequency corresponding to the frequency band either from the first or the second output of the mixer.

In accordance with a second aspect of the present invention there is provided a circuit for switching the frequency range of a radio receiver between first and second frequency bands comprising:

- means for providing a local oscillator signal having a frequency between the first and second frequency bands;
- means for mixing the local oscillator signal and a received signal to provide an output signal;
- means for providing the output signal to a first